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EFFECT OF SURFACE TREATMENT WITH REMINERALIZING ON THE COLOR STABILITY AND ROUGHNESS OF ESTHETIC RESTORATIVE MATERIALS

Efeito do tratamento de superfície na estabilidade de cor e aspereza em materiais restauradores estéticos

Prabhakar AR[a], Mahantesh T[b], Vishwas TD[c], Aparna Kabade[d]

[a] Professor and Head, Department of Pedodontics and Preventive Dentistry Bapuji Dental College and Hospital, Davangere, Karnataka, Índia, e-mail: attiguppeprabhakar@yahoo.com
[b] Reader. Department of Pedodontics and Preventive Dentistry, Bapuji Dental College and Hospital, Davangere, Karnataka, India
[c] Assistant Professor, Department of Pedodontics and Preventive Dentistry, Bapuji Dental College and Hospital, Davangere, Karnataka, India
[d] Post graduate student, Department of Pedodontics and Preventive Dentistry, Bapuji Dental College and Hospital, Davangere, Karnataka, India

Abstract

OBJECTIVES: The purpose of the study was to evaluate and compare the *in vitro* effect of fluoride varnish, APF gel and MI paste on the color stability and surface roughness of esthetic restorative materials. **MATERIAL AND METHODS**: 60 disks of each conventional glass ionomer and resin composite were made using molds of 1.2 cm x 2 mm. All the specimens were suspended in artificial saliva for 48 hours at 37ºC. Subsequently, fluoride varnish, APF gel, and MI paste were applied to all the subgroups except the controls. All the specimens were again suspended in artificial saliva and incubated at 37ºC for 24 hours. After incubation, they were cleaned using a toothbrush and toothpaste, and stored in the artificial saliva for 1 week. During this period, the specimens were subjected to color and surface roughness measurement. **RESULTS**: Measurements were expressed as mean ± standard deviation and compared between two groups by Student's t test. One way ANOVA was used for multiple group comparison and Tukey's test for pair wise comparison. **CONCLUSION**: The deterioration of GIC material was more rapid compared to composites when fluoride varnish, APF gels and GC Tooth Mousse were applied. The use of remineralizing agents on esthetic restorative materials causes changes in color and surface texture.

Keywords: Restorative materials. Color stability. Surface roughness. Remineralizing agents.

Resumo

***OBJETIVOS**: A finalidade deste estudo foi avaliar e comparar o efeito in vitro do verniz com flúor, do gel APF e da pasta MI na estabilidade de cor e aspereza de superfícies de materiais restauradores estéticos. **MATERIAL E MÉTODO**: 60 discos de cimento de ionômero de vidro convencional e 60 de resina composta foram produzidos usando moldes de 1,2 cm x 2 mm. Todos os corpos de prova foram mantidos em saliva artificial por 48 horas a 37ºC. Em seguida, verniz fluorado, gel APF e pasta MI foram aplicados a todos os subgrupos, com exceção do grupo controle. Todos os corpos de prova foram novamente imergidos em saliva artificial e incubados a 37ºC por 24 horas. Após a incubação,eles foram limpos utilizando escova de dentes e pasta, sendo mantidos em saliva artificial por uma semana. Durante esse período, os corpos foram submetidos a medições de coloração e de aspereza de superfície. **RESULTADOS**: As medidas foram expressas como medianas +- de desvio-padrão e comparadas entre dois grupos pelo teste t de Student. ANOVA foi usada para comparação entre grupos e o teste de Tukey foi utilizado para comparações por pares. **CONCLUSÃO**: A deterioração do ionômero de vidro foi mais rápida quando comparada com os compósitos pela aplicação de verniz com flúor, gel APF e pasta GC dental. O uso de agentes remineralizantes nas restaurações estéticas pode causar alterações de cor e textura de superfície.*

***Palavras-chave**: Materiais restauradores. Estabilidade de cor. Aspereza de superfície. Agentes remineralizadores.*

INTRODUCTION

Adhesive restorative materials have gained popularity due to their esthetic value and effectiveness in tissue preservation. In pediatric dental practice, Glass Ionomer Cements have been recommended for occlusal, proximal, labial and lingual restorations as well as the generation of sealants and orthodontic bands, tunnel restorations, cementation of stainless steel crowns. Composites are widely used in dentistry due to their excellent esthetics, adequate strength, moderate cost compared to that of ceramics and ability to micromechanically bond with the tooth structure (1, 2). Additionally, fluoride from different sources can be used to improve the condition of patients with a moderate or high risk of developing caries (3).

Professionally applied remineralizing agents such as APF, stannous fluoride, sodium fluoride can etch and stain esthetic restorative materials. Discoloration may be caused by surface staining, marginal staining due to microleakage, changes in surface morphology by wear and the deterioration of internal material (4). Change in color of these restorative materials is mainly attributed to change in chroma due to intrinsic or extrinsic factors (5). An increase in the surface roughness and discoloration has been used as a criterion to assess and predict the clinical deterioration of restorations constructed with different types of materials (6). Studies have been conducted to determine the reasons behind the deterioration of the esthetic restorative materials and the limitations of their physical properties. Therefore the main focus of this study is to determine the effect of fluoride varnish, APF gel and GC tooth mousse on the color stability and surface roughness of esthetic restorative materials.

MATERIAL AND METHOD

A total of 120 disk specimens of both the restorative materials were prepared. 60 disk specimens for each conventional glass ionomer (Fuji II, G.C. Corporation, Tokyo, Japan) and composite resin (Filtek Z-250 3 M ESPE Dental products, USA) were made using brass molds of 1.2 cm diameter x 2 mm thickness. Each material was labeled as Group A – conventional glass ionomer cement (Fuji II) and Group B – composite resin (Filtek Z-250) respectively.

GIC was manipulated according to the manufacturer's instructions. The cement was mixed at room temperature on a mixing pad with a plastic spatula and placed in a brass mold. The cement was then compressed between two mylar strips, sandwiched between two glass slabs and held under constant hand pressure until the cement was set. Each specimen was wet polished using a composite polishing kit. (Sof-Lex, 3M,U.S.A.)

Similarly, the required amount of composite material was placed in a brass mold, covered with mylar strips, sandwiched between two glass slabs and held under constant pressure. The material was light-cured using LED curing unit (Bee cool plus top light) for 40 seconds on each side. Individual disk was wet polished using the polishing kit. (Sof-Lex, 3M, U.S.A.)

60 specimens from Group A (GIC) and Group B (Composite) respectively were sub-divided into four different treatment groups (n =15) as shown in table I. The control group was not coated with any remineralizing agent.

Specimens were tested for color stability and surface roughness as follow:

1) Baseline evaluation - (Measurement I).
2) 48 hours of artificial saliva immersion – (Measurement II).
3) 24 hours following application of Fluoride varnish (Bifluorid 12 - VOCO, Cuxhaven, Germany), APF gel (Pascal Company Inc.) and MI paste (G.C. Corporation, Tokyo, Japan). The control group was not coated with remineralizing agent – (Measurement III).
4) After brushing with a manual tooth brush (Oral B) and tooth paste (Cologate Total – Cologate Palmolive Ltd, India) for two minutes - (Measurement IV)
5) After one week – (Measurement V).

Color measurements were performed using the Minolta Spectrophotometer (CM-330ld) with a 10mm aperture and D65 illuminant. The spectrophotometer was calibrated using the calibration plate provided by the manufacturer before each series of measurement. The baseline data for color measurement was recorded using CIE color parameters, L*, a* & b* where L refers to lightness or whiteness coordinate, with value range from 100 (perfect white) to zero (perfect black). The parameters a* and b* were recorded as chromaticity on red-green axis & yellow-blue axis respectively, with +a*- red, -a*- green, +b*- yellow, & -b*- blue. Each specimen was placed on natural grey background referred to as Munsell N-7 for standardized minimal background influence and color consistency. Specimens were then placed on the aperture and the base line reading "E (Total color change) was recorded as displayed on the computer (6). For surface roughness evaluation, each specimen was placed on a flat table. The tip of the profilometer (Tyalor and Hobson, England) was set to run on the surface and a baseline value Ra (Surface roughness) was obtained (7).

Following the base-line evaluation, each specimen was suspended in individual glass vial containing artificial saliva and stored at 37ºC for 48 hours. After 48 hours, all the specimens were blot to dry and the second measurement was performed for color change and surface roughness. Following the evaluation, a soft mini brush was used to apply the following coating materials – fluoride varnish, APF gel, MI paste to the respective subgroups as previously described. Upon coating, each specimen was dried for 4 minutes. All the specimens of Group A and Group B were suspended in artificial saliva and stored at 37ºC for 24 hours. Subsequently, the third measurement was performed. The fourth measurement was done after all the specimens were individually cleaned for two minutes with a manual toothbrush and toothpaste, and dried by holding between paper napkins. All the specimens were again immersed in artificial saliva for one week after with the fifth measurement was performed. The artificial saliva was replaced daily during the entire study period.

STATISTICAL ANALYSIS

The results were presented as mean ±SD. Statistical comparisons were performed using Analysis of Variance (ANOVA) for multiple groups and student's t test for two- group comparisons. Paired t-test was used for intra-group comparisons. A p-value of 0.05 or less was considered statistically significant.

RESULTS

Since individual specimens in each subgroup reacted differently, all results were compared to their respective base line values.

Nonetheless, the specimens initially behaved similarly since they were all kept in the saliva. Therefore measurements I & II are not depicted in table although readings were noted.

When the GIC and composites materials were compared for color changes after the application of fluoride varnish; no significant color change was observed for all the measurements performed. Similarly, after the application of MI paste, there was no significant difference in the color change of the materials. The application of APF gel also did not result in a significant difference in the color between the materials among the measurements performed; however, when L*, a* & b*, E values were compared to that at the end of the experiment, a significant color change was observed. A similar situation was observed for the measurements of the control specimens (Tables 1 and 2 and Graph 1, 3).

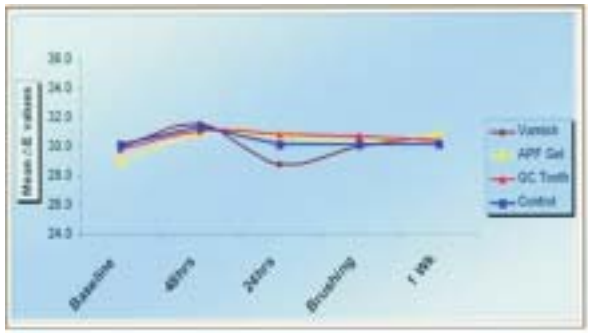
TABLE 1 - Comparison of various remineralizing agents with treatment groups - Group A: GIC, Group B: composite materials and storage time for different tests

Sub-group	Remineralizing Agents	Group A GIC	Group B Composite
1	Fluoride varnish	A1	B1
2	APF gel	A2	B2
3	G.C. Tooth Mousse	A3	B3
4	Control group	A4	B4

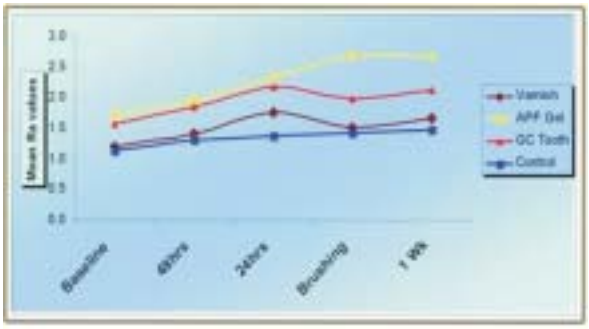
TABLE 2 - Comparison of color changes between GIC and composite following application of fluoride varnish, APF gel, GC tooth mousse

		Measurement II to III	Measurement III toIV	Measurement IV to V	Base line to End of the Experiment
Varnish	GIC	2.78 ± 2.30	- 1.27 ± 2.43	- 0.75 ± 1.96	- 0.77 ± 2.01
	Composite	2.23 ± 1.75	- 2.15 ±1.60	0.02 ± 0.33	0.19 ± 0.53
	GIC Vs	T 0.72	1.18	1.11	1.78
	Composite	P 0.48 (NS)	0.25 (NS)	0.29 (NS)	0.09 (NS)
APF	GIC	0.22 ± 1.01	0.39 ± 1.62	- 0.48 ± 1.39	-1.87 ± 1.86
	Composite	0.23 ± 0.29	- 0.11 ± 0.17	- 0.15 ± 0.22	0.12 ± 0.28
	GIC Vs	T 0.04	1.19	0.92	4.08
	Composite	P 0.97 (NS)	0.25 (NS)	0.37 (NS)	< 0.05 (S)
GC Tooth Mousse	GIC	0.21 ± 0.27	0.15 ± 0.45	0.33 ± 2.11	-0.57 ± 2.10
	Composite	0.25 ± 0.42	- 0.12 ± 0.65	0.05 ± 0.39	0.41± 0.62
	GIC Vs	T 0.31	1.34	0.51	1.73
	Composite	P 0.96 (NS)	0.19 (NS)	0.62 (NS)	0.10 (NS)
Control	GIC	- 0.39 ± 0.61	- 0.35 ± 1.07	- 0.01 ± 0.32	- 0.97 ± 1.40
	Composite	- 0.11 ± 0.08	- 0.04 ± 0.05	- 0.04 ± 0.01	0.24 ± 0.11
	GIC Vs	T 1.80	1.80	0.29	2.04
	Composite	P 0.09(NS)	0.30(NS)	0.78 (NS)	0.06 (NS)

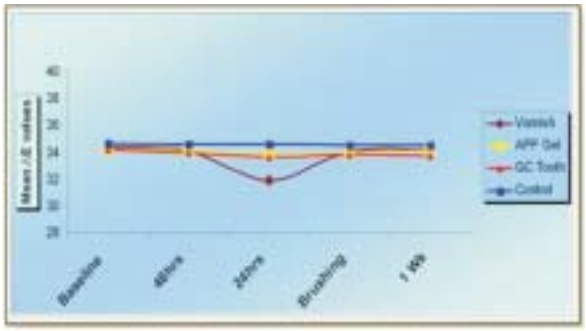
p<0.001 Highly Significant (HS).
p<0.05, p<0.01 Significant (S).
p>0.05 Not Significant (NS).



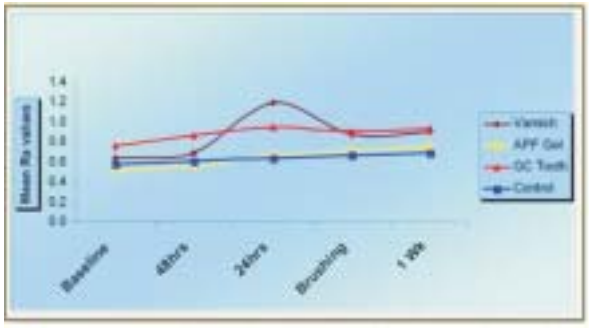
GRAPH 1 - Comparison of Changes in Color: GICmultinucleated cells – HE 100x



GRAPH 2 - Comparison of changes in surface roughness: GIC



GRAPH 3 - Comparison of changes in color: composite material



GRAPH 4 - Comparison of changes in surface roughness: composite material

When both materials were compared for surface roughness after the application of fluoride varnish, it was observed that there was no significant difference in the surface roughness values of the materials between measurements II and IV, but a significant change in surface roughness was observed between measurements IV and V. However, there was no significant change in surface roughness between the baseline measurement and the one at the end of the experiment.

The application of APF gel resulted in a significant difference in the surface roughness values of the materials. After the application of MI paste, a significant difference in the surface roughness of the materials was observed for all the measurements performed. When compare to control specimens, no changes were observed from the measurements II and III and from IV to V, while a significant change in roughness was observed from measurements III to IV. Additionally, comparison between the baseline measurement and the one at the end of the experiment revealed a significant change in surface roughness. (Table 3 and Graph 2, 4).

TABLE 3 - Comparison of surface roughness between GIC and composite following application of FLUORIDE VARNISH, APF GEL, GC TOOTH MOUSSE

		Measurement II to III	Measurement III toIV	Measurement IV to V	Base line to End of the Experiment
Varnish	GIC	-0.36 ± 0.03	0.26 ±0.29	-0.16 ± 0.20	- 0.46 ± 0.33
	Composite	-0.50 ± 0.32	0.32 ±0.33	-0.04 ± 0.03	-0.27 ± 0.21
	GIC Vs	T 1.21	0.53	2.36	1.90
	Composite	P 0.24 (NS)	0.06 (NS)	0.05 (NS)	0.07 (NS)
APF	GIC	-0.39 ± 0.61	-0.35 ± 1.07	- 0.01 ± 0.32	-0.97 ± 1.40
	Composite	-0.11 ± 0.08	- 0.04 ± 0.05	- 0.04 ± 0.01	0.24 ± 0.11
	GIC Vs	T 1.80	1.80	0.29	2.04
	Composite	P 0.09 (NS)	0.30 (NS)	0.78 (NS)	0.06 (NS)
GC Tooth Mousse	GIC	-0.33 ± 0.29	0.20 ± 0.22	-0.15 ± 0.14	-0.56 ± 0.43
	Composite	-0.09 ± 0.14	- 0.04 ± 0.06	-0.03 ± 0.02	-0.18 ± 0.26
	GIC Vs	T 2.86	2.67	3.20	2.93
	Composite	P <0.05 (S)	<0.05 (S)	<0.01 (S)	<0.01 (S)
Control	GIC	- 0.07 ± 0.25	- 0.05 ± 0.05	- 0.01 ± 0.32	- 0.97 ± 1.40
	Composite	- 0.03 ± 0.03	- 0.02 ± 0.06	- 0.04 ± 0.01	0.24 ± 0.11
	GIC Vs	T 0.70	1.07	2.07	2.35
	Composite	P 0.49(NS)	0.29 (S)	0.06 (NS)	<0.05 (S)

p<0.001 Highly Significant (HS).
p<0.05, p<0.01 Significant (S).
p>0.05 Not Significant (NS).

DISCUSSION

The two major groups of direct tooth-colored restorative materials used by dentists over the past 30 years are glass-ionomer cements and composites (1, 8).

Application of fluorides/remineralizing agents to the tooth surface is effective in preventing dental caries. The most commonly used professionally applied remineralizing agents are fluoride varnishes, acidulated phosphate fluoride (APF) gel and newer remineralizing agent CPP-ACP (GC Tooth Mousse). The primary reason for the popularity of fluoride varnishes is that its easy, safe, convenient to use, and its application follows a well-accepted procedure. The gel form of acidulated phosphate fluoride (APF) is widely used. (9, 10). The frequency of gel application varies depending on the caries risk level of the patient, and is usually recommended every 3 to 6 months (10, 11). It is also believed that application of APF gel may recharge the fluoride content of the exhausted cements (5, 12). The anticariogenic properties of milk and its products have been attributed to direct chemical effect of phosphoprotein casein and calcium phosphate. It has been suggested that casein phosphopeptides (CPPs) have the ability to stabilize calcium phosphate in solution by binding amorphous calcium phosphate (ACP) with their multiple phosphoserine residues, thereby allowing the formation of small CPP-ACP clusters. CPP-ACP prevents tooth demineralization and enhances remineralization (13).

Color stability and surface roughness are critical to the long-term success of esthetic restorations (6). Under regular oral conditions, esthetic restorations may be exposed to light, moisture, stain and mechanical wear, which often result in visibly detectable and esthetically undesirable color changes (1). Remineralizing agents used for reducing caries may also cause changes in color and surface roughness of the restorative materials. The present study was conducted to determine the effect of fluoride varnish, APF gel and GC tooth mousse on the color stability and surface roughness of esthetic restorative materials.

Application of fluoride varnish on the GIC material resulted in a significant change in color and surface roughness; however, after brushing no statistically significant color change was observed. The surface roughness was also reduced after brushing. The composite material also showed significant change in color after application of fluoride varnish. The difference in color was reduced after brushing and as it aged in the saliva, but the surface roughness was significantly increased. These results were comparable with those obtained in other studies (6, 9). It was observed that varnish application upon setting formed a layer on teeth or restorative material with an adherent film which might be the cause of the color change. Brushing causes decrease in color change probably due to partial the removal of the varnish layer. These studies have also reported that the composition and size of the filler particles affect both color and surface roughness of the restorative material. The relative susceptibility of glass ionomer to color change could be attributed to the porosity of the glass particles, while surface roughness seems to be more related to the cracking and porosity of the material. The discoloration of the composites may be due to larger particle size and possibly rougher surface. Another possible reason is that rough surfaces mechanically retain stains more efficiently than smooth ones (6). The varnish may be deposited in the rougher area of the restorative material, causing increased color change. The roughened surface of the material can be smoothened using a rotary polishing instrument (15).

In this study, application of APF gel on the GIC material resulted in significant color change at the end of the experimental period. There was also increase in surface roughness of the GIC material. These results were comparable with those from other studies where APF treatment increased the surface roughness of the GIC material (1, 3, 11, 16-18). El-Badrawy et al. (19) also suggested that phosphoric acid is capable of forming stable complexes with metal ions in the ionomer, resulting in greater surface erosion.

The application of APF gel on the composites resulted in a significant change in color and surface roughness, which is consistent with the findings of other studies (7, 19, 20, 21). The difference in color of the composite material could have been affected by the amount of inorganic filler content. The composite material used in this study, Z250, contains inorganic filler of 60% by volume. According to Dietschi et al. (22), a low staining susceptibility is related to high inorganic filler content of the composite material (20). It is suggested that the type of filler incorporated also influences the

surface characteristic of the composite material (11, 12, 23, 24) Filler particles appear to be the most likely sites of degradation. Unpolymerized materials are known to leach from cured resins depending upon the solvent (11). Additional evidence for degradation of filler particles by APF gel was shown by Bowen et al. (25) who observed the etching effect of acids on various experimental formulations of glass fillers (11).

When MI paste was applied to the GIC and composite materials, it was observed that there was initial change in color although no significant change was observed later on. However, there was significant change in the surface roughness throughout the experimental period. The initial change in color of both the materials could be due to the application of the GC Tooth Mousse, which was removed after brushing. The changes in color and surface roughness are due to the micro-porosities, which allow stain penetration and discoloration (6). The GC tooth mousse may be retained in these porosities, resulting in surface changes.

Although the control groups of both the materials did not show any significant change in color when immersed in saliva, there was a considerable change in the surface configuration. Studies have quoted that artificial saliva and other storage media such as lactic acid, deionized water and water can affect the chemical and physical characteristics of esthetic restorative material (7, 25).

When the GIC and composite were compared for color changes, it was observed that GIC demonstrated more color change compared to composite. Douglas W.H and Craig R.G (26) reported that hydrophilic materials stain more than hydrophobic materials. The GIC material exhibited greater color change compared to composites due to its hydrophilicity (6).

Similarly, when compared for surface roughness, the GIC demonstrated a more significant increase in surface roughness than the composites. The GICs are acid soluble while composites are acid insoluble (5). Furthermore, it was also observed that the roughness was due to the inclusion of voids which might be incorporated during the mixing or insertion of the material (27). Color stability and ability to resist stain may be potentiated by the surface conditions of the restorative material. A rougher surface affects color by increasing the scattering of the light incidence (1).

CONCLUSION

The observations in this study suggest that:

Fluoride varnish causes changes in color and surface roughness although change in color is transient.

APF gel application causes significant change in color and surface roughness of GIC and composite material.

GC tooth mousse causes minimal change in color and surface roughness.
GIC degrades more rapidly compared to composite material.

We recommend further *in vivo* research to evaluate the long-term effects of various remineralizing agents on esthetic restorative materials.

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